

REPORT DOCUMENTATION PAGE			Form Approved OMB NO. 0704-0188	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE		3. REPORT TYPE AND DATES COVERED Technical Report
4. TITLE AND SUBTITLE Title on Technical Report			5. FUNDING NUMBERS DAAH04-93-G-0505	
6. AUTHOR(S) Author(s) listed on Technical Report				
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES) Sam Houston State University Huntsville, TX 77341			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSORING / MONITORING AGENCY REPORT NUMBER ARO 32482.4-CH	
11. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12 b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)				
14. SUBJECT TERMS			15. NUMBER IF PAGES	
17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED			16. PRICE CODE	
18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED		19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED		20. LIMITATION OF ABSTRACT UL

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Environmental Life Cycle Costing Project

SADARM

Prepared for the US Army, PBMA, Picatinny Arsenal, NJ

by

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Environmental Life Cycle Costing Project SADARM

1.0 Purpose of This Study

This purpose of this study is to provide an estimate of the environmental cost of the SADARM munition over that munition's life cycle. Figure 1 identifies the various environmental costs identified by this study for each of the phases of the life cycle of the SADARM munition examined. Figure 1 also indicates, where appropriate, the percentage of costs for each activity that was determined to be environmentally driven based on the analysis of tasks within that activity.

Identifying the environmentally driven cost of a munition may contribute to decision making regarding issues such as materials selection during product design, design of the production process, selection of particular types or levels of operational training activities, etc. Understanding the full environmental cost, including environmentally related demilitarization costs, will support better decisionmaking regarding what products to produce and/or what factors may have adverse environmental impacts. The tools and general approach used to provide the estimate of SADARM environmental costs were drawn from the Activity Based Costing (ABC) framework. The life cycle of the SADARM munition was divided in to three phases: (1) Production (including Developmental Testing and Evaluation), (2) Operations and Support, and (3) Demilitarization.

The sections of this report that follow identify the methodology used to obtain estimates of the environmental activities and their costs that will be associated with SADARM over its life cycle, identification of the general assumptions made in order to complete this study, a discussion of the bounds of this study, and a discussion of the results with suggestions for further examination and study. Appended to this report are four appendices that describe in detail the data analysis of each of the phases of the SADARM life cycle examined in this study.

2.0 Methodology

This study used the Activity Based Costing (ABC) framework as the conceptual basis for addressing environmental life cycle cost. The ABC framework is built upon the concept that similar job tasks can be grouped by activity and the cost of the resources consumed by that activity can be determined. Once these determinations are made, the event or element that is the root cause of the tasks, and hence the activities, can be identified as the cost driver and a cost per event or element determined. In this manner the causes of costs are determined so that they can be managed.

2.1 Data Accumulation

The initial requirement of the ABC framework necessitates identification of the individual tasks performed by personnel in functional units that affect each of the life cycle phases. Once these tasks are identified, they are grouped into activities (i.e., groups of common tasks) based on similarity of effort and common purpose. The techniques of storyboarding (for groups) and interviews (for individuals) were used to accomplish these identifications and groupings. The initial step in these processes required individuals to indicate the tasks they carried out in performing their jobs. The tasks thus identified were recorded individually as the individuals "brainstormed" the jobs performed. The second step in the process involved having the participants group the tasks they identified based on their degree of common purpose. Once the tasks were grouped the individuals collectively provided a name for each of the groups.

The second step in applying the ABC framework requires the association of resources consumed with the activities that consume those resources. To accomplish this association each individual in the storyboarding process or interviews provided his or her own estimate of the percentage of resources consumed by each of the tasks within each activity group. These percentages were summed within each activity grouping to provide the overall percentage of resources consumed by that activity.

Step three of the data collection process involved identifying those tasks that either (1) have some degree of impact upon or (2) which are affected by environmental considerations. This step was accomplished in order to focus each group's attention on environmental issues that were related to the participant's daily tasks.

Step four of the data collection process involved using the collective expertise and experience of the participants to provide an estimate of the level of effort in each of the activity areas that is related to environmental considerations. To accomplish this, the individuals analyzed their listed tasks within each activity and provided an estimate of what percentage of the effort in accomplishing those tasks was related to environmental considerations.

The final step in the data collection process involved having the individuals classify the level of environmentally related effort identified in step four into five environmental objectives including prevention, detection, correction, disposal, and compliance.

2.2 Environmental Cost Determination

The costs of operations for each of the functional units that participated in each storyboarding sessions were obtained from accounting and control personnel at the appropriate location. These costs were multiplied by the estimates of the level of effort in each of the activity areas within each function to determine the total cost for each activity. The estimate of the level of environmentally-related effort within each activity was then used

to determine the total environmentally related cost for that activity. The estimates of the breakdown of environmentally related costs into environmental objectives were then used to determine, for example, the total Preventive costs incurred by the activity in question. This process was repeated for each activity within each function at each of the locations where the study took place.

After the total environmental cost for each activity was determined, that cost was related to the particular cost driver for that activity. In some cases, in keeping with the concepts of ABC, the cost driver used is a total product cost driver. For example, in the case of Production, the cost driver is the creation of the technology and processes necessary to manufacture the SADARM munition, regardless of the number of rounds that may be produced by that technology and those processes. For this reason, the environmental costs of Production are quantified in terms of the total SADARM contract rather than on a per unit basis. In the case of the Support and Operations phase of the life cycle, the activities and costs are driven by the number of rounds that will be fired per year. This relationship is based on the concept that if a SADARM round is not fired in field operations, then there will be no activities accomplished in for the munition and hence, no environmentally related costs. Therefore, the environmentally related costs identified in the Support and Operations phase of the life cycle are measured on a per round fired basis.

3.0 General Assumptions of This Study

In order to complete this study, a number of assumptions were necessary given the fact that many of the elements associated with the SADARM life cycle have yet to be specifically identified and described (e.g., annual operational training requirements). A number of these assumptions applied to the overall study and others applied only to specific phases of the life cycle. Listed below are the general assumptions made regarding the overall project. The assumptions that apply only to a particular phase of the life cycle are listed at the beginning of each of the appendices of this study where the data and the cost analysis for each specific life cycle phase is provided.

3.1 This study begins with the Production phase of the SADARM life cycle. Activities and environmental costs that occurred in phases prior to that point are not considered due to scheduling and resource constraints.

3.2 In the Production phase of this project, only the production related activities of the Aerojet Corporation were examined. No other contractor or subcontractor activities were examined.

3.3 The assumption is that the conventional 155mm artillery round provides the necessary surrogate for the SADARM round in assessing the environmental life cycle costs.

3.4 In both the Operations and Support phase and in the Developmental Test and

Evaluation task, the assumption for purposes of this study is that there will be no environmental cleanup of the impact areas used for training and testing.

3.5 This project assumes that all environmental activities identified are based on currently existing environmental laws and regulations. In no way does this study anticipate laws or regulations that may be in place during the total life of the munition beyond those which currently exist.

3.6 The Demilitarization phase is not addressed at this stage of the environmental life cycle costing project due to the fact that demilitarization requires a specific plan of activities and tasks to be carried out. At the present time, this plan is under development. No assessment of future environmental costs associated with demilitarization is possible until the specific elements of this plan are known.

3.7 This study does not address the question of contingent liabilities that may arise in the future regarding the SADARM munition in relation to environmental issues.

4.0 Scope of the Study

A number of factors combined to set the bounds of this study. Scheduling, time requirements, and resource availability acted to limit the degree to which some issues could be addressed. An additional limiting factor involved the fact that many of the issues relevant to the analysis of the life cycle of the SADARM munition have yet to be addressed from a planning or from an operational standpoint (e.g., the operational training requirements for SADARM have yet to be specified). The particular bounds involved are identified in the following paragraphs.

4.1 Bounds of the Study

This study begins with the Production phase of the life cycle and does not address the creation of the components used in that phase. A full life cycle includes the creation, from raw materials, of the component elements of the product. Given the scheduling and time requirements for this study, an examination of pre-production life cycle phases was not possible.

No contractor or subcontractor activities other than those of the Aerojet Corporation were examined. Given the advanced state of the development of the SADARM contract and the resource and scheduling constraints of this study, examination of these non-Aerojet activities was not possible.

This study does not address the issue of contingent liabilities in relation to the SADARM munition. While contingent costs represent costs that may or may not be incurred at some point in the future, these costs can be addressed in probabilistic terms. Although these costs will have to be addressed in a full examination of an environmental life cycle,

this study did not accomplish such an examination due in part to scheduling and resource constraints but also due to the lack clear agreement by accountants and other interest parties as to the proper way to address this issue.

The Demilitarization phase of the life cycle was not specifically addressed by this study. The reason for this omission is that to accomplish an analysis of the environmental costs of demilitarization, there must exist a fully developed plan for the demilitarization of the SADARM munition. Given that the demilitarization plan was under development concurrently with this study, the necessary cost analysis of that plan was not possible.

Currently existing environmental laws and regulations form the regulatory framework under which this study was accomplished. While environmental laws and regulations may change during the life cycle of the SADARM munition, no attempt was made to anticipate changes in these factors or assess their impact upon the costs of the SADARM munition.

4.2 Areas Analyzed in the Study

To address the Production phase of the life cycle, a number of functional areas of the Aerojet Corporation were analyzed in this study. The functional areas analyzed were the production assembly operations, the facilities and environmental health and safety area, the project management and management data functions, and the systems and test engineering areas. The costs for each of these areas were extracted from the work breakdown schedule of the low rate production contract for SADARM munitions. The unit of measure for the Production phase used in this study is the entire low rate production contract. The rationale for this measure is that the primary cost drivers identified in the various Production functions are tied to the creation of the technology and the processes used to produce the SADARM munition rather than being tied to the production of a particular number of rounds of that munition.

The Developmental Testing segment of the Production phase of the life cycle was examined through analysis of operations at the Yuma Proving Ground, Yuma, Arizona. The functional areas examined at that facility included ammunition processing (for test operations), actual test operations, and Environmental division activities. For the ammunition processing and testing activities, the actual costs involved in testing the SADARM munition for FY 94 were used along with the estimated levels of environmental costs involved. For the environmental division activities (all of which were assumed to be environmentally related) budgeted costs for the operation were used. The unit of measure for the Developmental Testing element of the Production life cycle phase used in this study is the actual testing program accomplished to support the SADARM low rate production contract. Utilization of this unit of measure was possible due to the fact the low rate production testing has been completed.

The Operations and Support phase of the life cycle was examined at Ft. Hood, Texas. The pertinent functions identified at that facility that included operations (1st Cavalry and 2nd Armored divisions), logistics (warehousing and processing), range operations, and the base environmental division. For the operations function costs, the annual budgeted costs for a 155mm artillery battalion were used in the analysis. For the logistics function, the budgeted costs for the ordnance warehouse unit were used for the analysis. For the range operations and the environmental division, the annual budgets for these functions were used. The unit of measure used as the cost driver for the Operations and Support phase of the life cycle is the round fired. Environmental costs are incurred in this phase of life cycle due to a round being fired by the operating units. Because SADARM is designed to be a "wooden" round (i.e., it requires not continuous maintenance or attentions), only during actual firing of the munition will environmental activities occur.

5.0 Results and Suggestions for Further Examination

A number of areas for further study and a number of conclusions were identified during and as the result of this study. These issues are identified in the following discussions.

5.1 The identification of environmentally driven activities and their related costs over the life cycle of a weapon system requires the application of a conceptually driven process of analysis such as the methodology used in this study. The viability of a static formula or mathematical model in addressing environmental life cycle cost issues for other than a one-time analysis item is highly questionable. While variables in a model may be manipulated, modeled relationships are valid only if the relationships among variables in a new set of circumstances are identical to those upon which the model is based. One cannot apply the existing model to new conditions without a complete revision of that model - reinventing of the wheel for each new proposed weapon system. A methodological approach that is based upon the analysis of relationships among factors in unique situations provides a framework with the flexibility necessary to address new situations and conditions. Although the initial development of a model requires the analysis of relationships, the application of a model to new circumstances generally involves only the identification of the quantities of the variables to be input with no concern for the fact that the relationships among variables in the new circumstances may differ from those included in the model. A methodological approach recognizes that the analysis methodology must be applied to each new set of circumstances and the relationships present in those conditions identified.

One lesson learned from the present study is that while proposed weapon systems, such as SADARM, may be similar in some respects, technologically complex system have individually unique components, elements, associated processes, etc. Therefore, in order to identify the environmentally related issues and costs associated with unique systems, a system specific analysis must be accomplished. For this reason, the development of a methodology or process rather than the development of a model or computer program is, in our opinion, a superior means of addressing environmental costs over the life cycle of proposed weapon

systems. Proposed systems have, to name a few, differing life cycles, production processes, operational requirements, demilitarization activities, technological components, and component materials. The environmental activities and related costs that will be necessary to deal with these differing factors must be uniquely identified in any attempt to address those activities and costs. There are no "magic buttons" or model computer programs that can be used to generically analyze environmentally related activities. If such buttons or programs were to be developed, they would of necessity be project or product specific and would require a complete revision in order to apply them to analyze additional projects or products. However, development of a methodology that is based conceptually on Activity Based Costing will provide the guidance and framework to accomplish the necessary unique initial analysis of environmental issues, activities, and costs of uniquely differentiated proposed weapon systems.

5.2 Examination of production contractor and subcontractor activities beyond the "top" level of production are necessary. In order to fully identify and quantify the complete life cycle environmental costs for a product, all activities directed toward the production of that product are necessary. If the environmental costs of SADARM are to be more completely identified, then the time and resources must be provided to examine the subcontractor and other levels of production activity.

5.3 The Demilitarization phase of the life cycle must be examined in relation to the Demilitarization Plan that is developed for SADARM. Because demilitarization will take place in the future, identification of future activities and their costs will require projections by the parties that will accomplish the demilitarization process. Before these parties can accomplish any such projections, the plan under which they will operate must be specified.

5.4 To more accurately address the environmental costs of the Operations and Support phase of the life cycle, the actual operational training, support, and logistics plans to be accomplished by units in that phase should be examined. In the case of the SADARM munition, the existence of an appropriate surrogate round (i.e., the conventional 155mm round) made analysis of this area possible even in the absence of any specific guidance regarding operational or support requirements.

5.5 The excellent participation in this study by contractor, developmental testing, and operational personnel was obtained based on the respective unit's desire to be cooperative with the military units that directed this study. For this reason, the cooperating units were required to commit resources to this study that would have been employed in more direct mission support activities. If environmental life cycle cost studies are to be carried out in the future, provisions should be made that do not require the cooperating units to "donate" the resources to help accomplish those studies. While the present study in no way suffered due to this situation, further studies that consume increasing amounts of cooperating unit resources may not be so fortunate.

5.6 The concepts of Activity Based Costing provide a framework that is useful for

identification of environmentally related activities and costs. The technique of storyboarding successfully elicited the necessary information from the individuals who are actually accomplishing the environmentally driven tasks in the life cycle. The application of that technique in a group setting results in the counterbalancing of any bias that one or a few individuals may have in regard to the issues being addressed. The environmental objective classification scheme appears to be a workable scheme for classifying environmental costs in regard to objectives. There is some evidence that this classification scheme will support management decision making in regard to the levels of expenditures in relation to particular objectives and to the trade offs possible between those expenditures.

6.0 Definitions

Life Cycle Phases:

Production: that portion of the life cycle in which the product is created from its basic components, is completed, and is delivered to the customer

Operations and Support: the phase of the life cycle in which the item (e. g., the SADARM munition) is fielded and under the control of the operating units, beginning with receipt from the contractor and ending when the munition is removed from the active inventory for demilitarization or disposal

Demilitarization: the final phase of the life cycle during which the item (e.g. the SADARM munition) is removed from service (a particular unit, lot, or even the entire system) and is decommissioned, disassembled (as necessary). and disposed of in an appropriate manner

Environmental Cost Objectives:

Preventive: costs incurred in order to prevent or minimize adverse environmental events; the costs of upfront, proactive activities and steps taken to address environmental issues prior to their occurrence

Detective: costs incurred in order to provide surveillance of activities and tasks to determine if an adverse environmental event has occurred; the costs associated with monitoring, inspecting, and testing to determine the occurrence of environmental events that require further action

Corrective: costs incurred in order to restore, remediate, or clean up the results of an adverse environmental event; costs incurred to respond to an adverse environmental event.

Disposal: costs incurred by a particular function or activity to destroy the materials, wastes, or other items in question or to transfer responsibility for those materials, wastes, or

other items to another entity.

Compliance: the paperwork, recordkeeping, permitting, and reporting necessary to prove compliance with federal, state, and local environmental laws and regulations

Figure 1
**SADARM Environmental Life Cycle Cost
 Cost Summaries**

Production Phase:

Contractor - Aerojet General		
Total Cost Analyzed	\$ 15,873,854	during LRP
Total Environmental Cost	\$ 1,689,892	during LRP
Environmental as a % of Total	10.64%	
Developmental Test and Evaluation		
Total Cost Analyzed	\$ 1,203,191	FY 94 testing
Total Environmental Cost	\$ 188,465	FY 94 testing
Environmental as a % of Total	15.66%	

Operations and Support Phase:

Tactical Operations		
Total Cost Analyzed	\$ 2,633	per round fired
Total Environmental Cost	\$ 783	per round fired
Environmental as a % of Total	29.75%	
Logistics Support		
Total Cost Analyzed	\$ 91	per round fired
Total Environmental Cost	\$ 30	per round fired
Environmental as a % of Total	32.75%	
Range Operations		
Total Cost Analyzed	\$ 107	per round fired
Total Environmental Cost	\$ 64	per found fired
Environmental as a % of Total	59.49%	
Environmental Department		
Total Environmental Cost	\$ 37	per round fired

Demilitarization Phase:

To be addressed after development of the demilitarization plan for SADARM.

Appendix A

Production

Primary Location: Aerojet General Corporation, Azusa, California

Assumptions:

1. This study begins with the Production phase of the SADARM life cycle. Activities and environmental costs that occurred in phases prior to that point were not considered due to scheduling and resource constraints.
2. In the Production phase of this project, only the production related activities of the Aerojet Corporation were examined. No other contractor or subcontractor activities were examined. The time and resource constraints of this demonstration project prevented examination at other than the top level of production activities. However, the methodology and techniques applied to the Aerojet activities should be applied to all contractors and subcontractors in a full scale environmental life cycle costing examination.
3. For the purposes of this study, the event of disposal of wastes and materials in the Production phase is considered to be any direct actions taken by the contractor. The contractor may directly dispose of the items in question through such processes as demolition, burning, burying, or by transfer of the material to an approved disposal area. Once the material or item is no longer the responsibility of the contractor, it is considered to be disposed of by the contractor even though the item may not have reached its final disposal condition.

Appendix B

Developmental Testing

Primary Location: Yuma Proving Ground, Yuma, Arizona

Assumptions:

1. In the Developmental Test and Evaluation components of the Production phase, the assumption is that testing will be accomplished at the Yuma test facility. If another testing facility were to be selected, then the environmental costs of that particular test facility would have to be determined and included in the analysis.
2. The assumption for purposes of this study is that there will be no environmental cleanup of the impact areas used for testing. Therefore, no environmental cleanup costs for impact area remediation are included in the cost quantities used in this study.

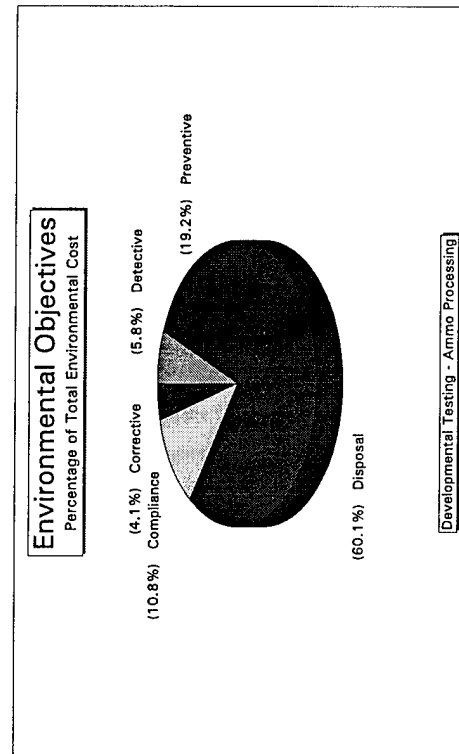
Environmental Life Cycle Cost Analysis Summary Developmental Testing

Developmental Testing: Ammo Processing
Reference: 5.0

Activities	SADARM Activity Total Cost	Environmentally Driven % of Total	Environmental Objectives		
			Type	Cost Impact	%
5.1 Inspection	\$9,648	20.0%	Preventive	\$7,911	19.2%
5.2 Administration	9,648	10.0%	Detective	\$2,412	5.8%
5.3 Warehousing	14,472	10.0%	Corrective	\$1,688	4.1%
5.4 Salvage Operations	6,754	90.0%	Compliance	\$4,438	10.8%
5.5 Ammo Preparation	14,472	20.0%	Disposal	\$24,796	60.1%
5.6 SOP Preparation	4,824	10.0%			
5.7 Training	2,894	15.0%			
5.8 Test Coordination	4,824	20.0%			
5.9 Demilitarization	28,945	90.0%			
Total Activities	\$96,481		Total SADARM Environmental	\$41,246	100.0%
			Total SADARM Ammo Processin	\$96,481	
			Total Environmental as % of Total SADARM	42.75%	

Note:

- Costs of SADARM based on percentage of actual SADARM cost as a percentage of actual total testing costs in FY94.



Development Testing: Ammo Processing
Activity: Inspection

Reference: 5.11

Total Activity Cost : \$9,648
Environmentally Driven % of Total: 20.0%
Environmentally Driven Cost: \$1,930

Tasks: storage bunker inspection, inspect loads, inspect ammo, warehouse inspection, determine ammo condition codes, coordinate shipping, QA/QC documentation, inspect vehicles, determine stockpile compatibility, issue ammo, issue ammo, classify ammo

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	10.0%	\$965
Detective	10.0%	965
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	0.0%	0
Total	20.0%	\$1,930

Development Testing: Ammo Processing
Activity: Administration

Reference: 5.21

Total Activity Cost : \$9,648
Environmentally Driven % of Total: 10.0%
Environmentally Driven Cost: \$965

Tasks: paperwork control, ammo counts, planning meetings, work scheduling,
turn in documentation, process requests for ammo issue

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	0.0%	\$0
Detective	0.0%	0
Corrective	0.0%	0
Compliance	10.0%	965
Disposal	0.0%	0

Total	10.0%	\$965
=====		

Development Testing: Ammo Processing
Activity: Warehousing

Reference: 5.31

Total Activity Cost : \$14,472
Environmentally Driven % of Total: 10.0%
Environmentally Driven Cost: \$1,447

Tasks: inventory incoming items, generate paperwork, rewarehouse ammo, warehouse maintenance, track and inventory ammo, maintain ammo database, ammo breakdown and labeling, observe ammo preparation, pack fired rounds for transportation, loading trucks for magazine storage area, transport ammo to preparation area, repack ammo, store packaging material

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	5.0%	\$724
Detective	0.0%	0
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	5.0%	724
Total	10.0%	\$1,447
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Development Testing: Ammo Processing
Activity: Salvage Operations

Reference: 5.41

Total Activity Cost : \$6,754
Environmentally Driven % of Total: 90.0%
Environmentally Driven Cost: \$6,079

Tasks: salvage packaging, recycle dunnage, dispose of surplus packing, dispose of cleaning materials,
spill reporting, acetone storage, excavate spills, store range residue

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	0.0%	\$0
Detective	0.0%	\$0
Corrective	0.0%	\$0
Compliance	5.0%	\$338
Disposal	85.0%	\$5,741
Total	90.0%	\$6,079

Development Testing: Ammo Processing
Activity: Ammo Preparation

Reference: 5.51

Total Activity Cost : \$14,472
Environmentally Driven % of Total: 20.0%
Environmentally Driven Cost: \$2,894

Tasks: wax load ammo, return unfired ammo to preparation, assemble ammo, condition ammo,
remark returned items, dispose of packing, clean threads, paint ammo rounds

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	15.0%	\$2,171
Detective	0.0%	0
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	5.0%	724
Total	20.0%	\$2,894

=====

Development Testing: Ammo Processing
Activity: SOP Preparation

Reference: 5.61

Total Activity Cost : \$4,824
Environmentally Driven % of Total: 10.0%
Environmentally Driven Cost: \$482

Tasks: prepare SOPs for ammo disassembly, pilot runs for test, write recovery procedures,
do hazard analyses, review/monitor all areas for safety, research procedures

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	5.0%	\$241
Detective	0.0%	0
Corrective	5.0%	241
Compliance	0.0%	0
Disposal	0.0%	0
Total	10.0%	\$482

Development Testing: Ammo Processing
Activity: Training

Reference: 5.71

Total Activity Cost : \$2,894
Environmentally Driven % of Total: 15.0%
Environmentally Driven Cost: \$434

Tasks: on-site training, maintain respirators, obtain information for environmental group

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	15.0%	\$434
Detective	0.0%	0
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	0.0%	0
Total	15.0%	\$434

Development Testing: Ammo Processing
Activity: Test Coordination

Reference: 5.81

Total Activity Cost : \$4,824
Environmentally Driven % of Total: 20.0%
Environmentally Driven Cost: \$965

Tasks: prepare for firing test, attend test scheduling meeting, coordinate with contractors,
daily ammo control meetings, review test schedule, plan for testing

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	10.0%	\$482
Detective	0.0%	0
Corrective	0.0%	0
Compliance	5.0%	241
Disposal	5.0%	241
Total	20.0%	\$965

Development Testing: Ammo Processing
Activity: Demilitarization

Reference: 5.91

Total Activity Cost : \$28,945
Environmentally Driven % of Total: 90.0%
Environmentally Driven Cost: \$26,051

Tasks: store explosives, store ammo at ammo plant, store unfired ammo, disassemble ammo, inspect impact areas, burn/detonate excess propellant, maintain disposal logs, recover fired rounds, prepare spent material for return, burn/dispose of excess explosives, clean impact areas, coordinate with environmental group, range clearance, burn/dispose of boosters, monitor weather, excavate fired rounds, field maintenance, escort regulators/inspectors, escort range visitors, breakdown fired ammo rounds

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	10.0%	\$2,895
Detective	5.0%	1,447
Corrective	5.0%	1,447
Compliance	10.0%	2,895
Disposal	60.0%	17,367
Total	90.0%	\$26,051
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Environmental Life Cycle Cost Analysis Summary

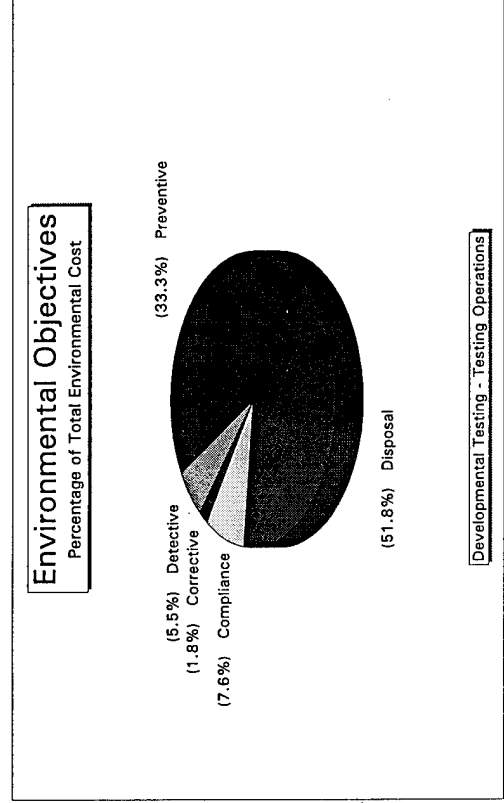
Developmental Testing

Developmental Testing: Testing Operations
Reference: 6.0

Activities	SADARM Activity Total Cost	Environmentally Driven % of Total	Environmental Cost	Environmental Objectives		
				Type	Cost Impact	%
6.1 Test Preparation	\$186,096	5.0%	\$9,305	Preventive	\$44,991	33.3%
6.2 Training	54,734	20.0%	10,947	Detective	7,444	5.5%
6.3 Pre-test & Inspection	240,830	10.0%	24,083	Corrective	2,408	1.8%
6.4 Test Firing	503,556	5.0%	25,178	Compliance	10,290	7.6%
6.5 Post Test	109,468	60.0%	65,681	Disposal	70,060	51.8%
Total Activities	\$1,094,684	for FY 94	\$135,193	Total SADARM Environment	\$135,193	100.0%
				Total SADARM Testing	\$1,094,684	
				Environmental as % of Total	12.35%	

Note:

- Activity costs are based on actual SADARM testing costs as a percentage of total testing costs for FY94.



Developmental Testing Testing Operations
Activity: Test Preparation

Reference: 6.11

Total Activity Cost : \$186,096
Environmentally Driven % of Total: 5.0%
Environmentally Driven Cost: \$9,305

Tasks: assign priorities, provide information for future tests, attend planning meetings, interface with offsite contractors, write SOPs, process schedule requests, rescheduling, interface with state and unit environmental personnel, coordinate with test engineers, handcarry paperwork at base, document measurements, answer memos, handle SFG, maintain records of material usage, maintain training records, plan testing, cost estimating, document materials usage, evaluate resources to be used, develop test equipment, software development, inspect equipment, adapt equipment for testing, calibrate equipment, coordinate testing with environmental department, scheduling meetings, prepare test schedule, monitor test equipment, develop new equipment specifications, maintain and upgrade equipment

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	4.0%	\$7,444
Detective	0.0%	0
Corrective	0.0%	0
Compliance	1.0%	1,861
Disposal	0.0%	0
<hr/>		
Total	5.0%	\$9,305
	=====	=====

Reference: 6.21

Total Activity Cost :	\$54,734
Environmentally Driven % of Total:	20.0%
Environmentally Driven Cost:	\$10,947

Tasks: certification training, on-the-job training, respirator training, driver track training, HAZMAT training, new equipment training, ammo training, handling of new coolant materials, maintain freon equipment, new equipment acquisition, toxic materials training, dry runs on new systems

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	19.0%	\$10,399
Detective	0.0%	0
Corrective	0.0%	0
Compliance	1.0%	547
Disposal	0.0%	0
Total	20.0%	\$10,947

Developmental Testing Testing Operations
Activity: Pre-Test & Inspection

Reference: 6.31

Total Activity Cost : \$240,830
Environmentally Driven % of Total: 10.0%
Environmentally Driven Cost: \$24,083

Tasks: tube measurement, measure projectile, pre and post test measurements, X-ray equipment, flash X-rays, ultrasonic cleaning, clean copper pressure gauges, pre-test inspections, recover and measure fired items, tube cleaning, maintain condition data on tubes, non-destructive testing, test fluid samples, sample and analyze fluids, monitor tube conditions, inspect equipment

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	5.0%	\$12,042
Detective	1.0%	2,408
Corrective	1.0%	2,408
Compliance	1.0%	2,408
Disposal	2.0%	4,817
Total	10.0%	\$24,083

Developmental Testing Testing Operations
Activity: Test Firing

Reference: 6.41

Total Activity Cost : \$503,556
Environmentally Driven % of Total: 5.0%
Environmentally Driven Cost: \$25,178

Tasks: pre-test setup, moving guns, gun setup, transport equipment, test setup, transfer test items, thermal preparation for firing, range incident reporting, prepare firing reports, prepare condition reports, transport to test area, coordinate gun placement with environmental department, generate charts, destructive testing, prepare dud reports, document tests, instrument testing, test firing, collect firing test data, unpack test items, conduct high/low/humidity tests, calculate PSI from tests, replenish and maintain carbon dioxide

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	3.0%	\$15,107
Detective	1.0%	\$5,036
Corrective	0.0%	\$0
Compliance	0.0%	\$0
Disposal	1.0%	\$5,036
Total	5.0%	\$25,178

Developmental Testing Testing Operations
Activity: Post Test

Reference: 6.51

Total Activity Cost : \$109,468
Environmentally Driven % of Total: 60.0%
Environmentally Driven Cost: \$65,681

Tasks: post-firing cleaning, salvage pallets, dispose of oily rags, cleanup of materials and soils on major spills, cleanup of fluid spills, fluid recovery, monitor equipment spills and emissions, repacking items, salvage dunnage, containment of spills, dispose of excess powder and residue, replace fluids, recover packing material after firing, return unfired ammo, collected fluids after testing

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	0.0%	\$0
Detective	0.0%	0
Corrective	0.0%	0
Compliance	5.0%	5,473
Disposal	55.0%	60,207
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Total	60.0%	\$65,681
	=====	=====

Environmental Life Cycle Cost Analysis Summary

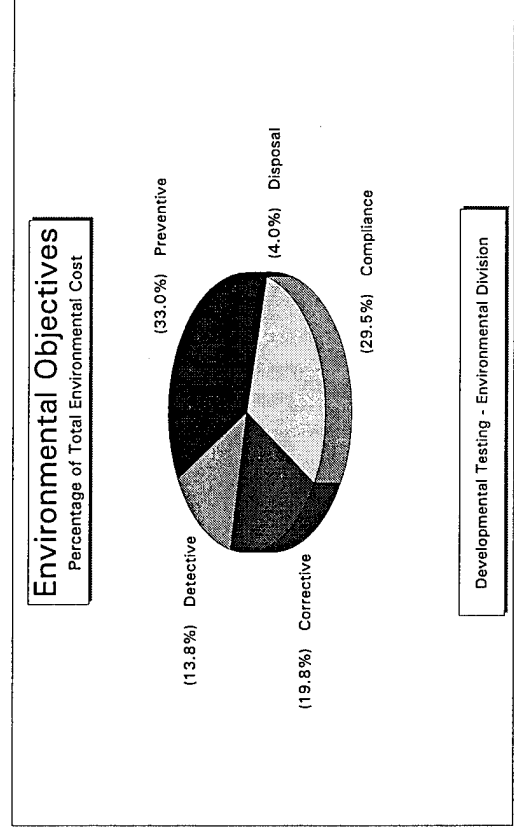
Developmental Testing

Developmental Testing: Environmental Division
Reference: 7.0

Activities	SADARM Activity Total Cost	Environmentally Driven % of Total	Environmental Objectives		
			Type	Cost Impact	%
7.1 Inspection	\$601	100.0%	Preventive	\$3,968	33.0%
7.2 Field Work	1,203	100.0%	Detective	1,654	13.8%
7.3 Administration	2,405	100.0%	Corrective	2,375	19.8%
7.4 Technical Compliance	4,810	100.0%	Compliance	3,548	29.5%
7.5 Technical Support	3,007	100.0%	Disposal	481	4.0%
Total Activities	\$12,026 annually		Total SADARM Environmental	\$12,026	100.0%
			Total Environmental Division	\$786,000	
			SADARM Environmental as % of Total Environmental Division		1.53% for FY 94

Note:

- Costs shown for SADARM are based on the actual SADARM testing costs as a percent of total testing cost for FY94.



Developmental Testing Activity: Environmental Division Inspection

Reference: 7.11

Total Activity Cost : \$601
 Environmentally Driven % of Total: 100.0%
 Environmentally Driven Cost: \$601

Tasks: inspect RCRA points, inspect hazardous waste sites, chemical weapons material inspections, respond to state inspectors, escort regulators and inspectors

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	25.0%	\$150
Detective	75.0%	451
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	0.0%	0
Total	100.0%	\$601
	=====	=====

Developmental Testing Environmental Division
Activity: Field Work

Reference: 7.21

Total Activity Cost : \$1,203
Environmentally Driven % of Total: 100.0%
Environmentally Driven Cost: \$1,203

Tasks: manage natural resource contracts, waste inspections, drive around base, ground water monitoring, NRC licenses, complete surveys, inspect area analysis for testing, inventory cultural resources, review laboratory results, plan field work, document side effects of tests, analyze water samples, wildlife inventory, plant inventory, coordinate field work, bat surveys, contract cultural resource work, monitor landfill emissions, biological research

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	15.0%	\$180
Detective	80.0%	962
Corrective	5.0%	60
Compliance	0.0%	0
Disposal	0.0%	0

Total	100.0%	\$1,203
	=====	=====

Developmental Testing Activity: **Environmental Division Administration**

Reference: 7.31

Total Activity Cost : \$2,405
 Environmentally Driven % of Total: 100.0%
 Environmentally Driven Cost: \$2,405

Tasks: deal with hazardous waste inspections, coordinate with testing schedule, communicate needs and requirements, respond to phone calls, TAR appraisals, personnel management, environmental infrastructure

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	70.0%	\$1,684
Detective	0.0%	0
Corrective	5.0%	120
Compliance	25.0%	601
Disposal	0.0%	0
Total	100.0%	\$2,405

Developmental Testing Environmental Department
Activity: Technical Compliance

Reference: 7.41

Total Activity Cost : \$4,810
Environmentally Driven % of Total: 100.0%
Environmentally Driven Cost: \$4,810

Tasks: analyze effects of past pollution, prepare safety and health plans, inventory supplies and equipment, review regulations, review tests, permitting, cleanup test sites, Title 5 air permitting, prepare specifications for cleanup of solid wastes, waste water permitting, inspect hazardous waste generation sites, plan upgrade of water system, permits for drinking water, coordinate remediation, test support record of environmental considerations, used tire/oil/battery reports, solid waste landfill permitting, prepare permit applications, environmental review, review conformity requirements, prepare remediation work plans, review test plans, review federal registers, review state regulations, attend meetings, training, negotiate with regulators, monitor and report underground storage and pipelines, Title V permit applications, manage CFCs, operate solid waste landfill, calibrate leak detection apparatus, NEPA review for proposed tests

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	25.0%	\$1,203
Detective	5.0%	\$241
Corrective	30.0%	\$1,443
Compliance	30.0%	\$1,443
Disposal	10.0%	\$481
Total	100.0%	\$4,810
	= = = = =	= = = = =

Developmental Testing Activity: Environmental Department Technical Support

Reference: 7.51

Total Activity Cost : \$3,007
 Environmentally Driven % of Total: 100.0%
 Environmentally Driven Cost: \$3,007

Tasks: 1383 submissions paperwork, monitor database, generate environmental resource report, prove spending and charge, review budget, develop charge rates, general environmental review reports, coordinate and acquire funds for tests, track hazardous wastes, process e-mail, reporting, respond to spills, individual data entry, generate work plans, hazardous waste inventory, coordinate environmental training for Yuma and MCAS Yuma, health tracking, upgrade fire training, attend offsite environmental training

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	25.0%	\$752
Detective	0.0%	0
Corrective	25.0%	752
Compliance	50.0%	1,504
Disposal	0.0%	0
Total	100.0%	\$3,007
	=====	=====

Appendix C

Operations and Support

Primary Location: Ft. Hood, Texas

Assumptions:

1. The assumption is that the conventional 155mm artillery round provides the necessary surrogate for the SADARM round in assessing the environmental life cycle costs. The use of this surrogate is necessary given that SADARM is under development and has yet to be a part of the Operations and Support phase activities. The activities and tasks identified in this phase are, therefore, related to conventional 155mm artillery operations.
2. The assumption for purposes of this study is that there will be no environmental cleanup of the impact areas used for training. Therefore, no environmental cleanup costs for impact area remediation are included in the amounts indicated in this study.
3. In the Operations and Support phase for Tactical Operation activities, the assumption is that environmental costs are incurred in field training due to the firing of live SADARM rounds. An estimate of 100 rounds per year is used for the quantity involved in this activity. Actual operational training firing requirements (when established) would have to be used in order to determine the estimated environmental cost associated with this activity over the full life cycle.
4. In the Operations and Support phase for Logistics activities, the assumption is that the number of rounds issued is the driver for environmental costs. The various tasks in this area occur in relation to the issuance of rounds for firing purposes.
5. For the purposes of this study, the event of disposal of wastes and materials in the Operations and Support phase is considered to be any direct actions taken by the field unit in question. The unit may directly dispose of the items in question through such processes as demolition, burning, burying, or by transfer of the material to an approved disposal area. Once the material or item is no longer the responsibility of the unit, it is considered to be disposed of by the unit even though the item may not have reached the final disposal condition.

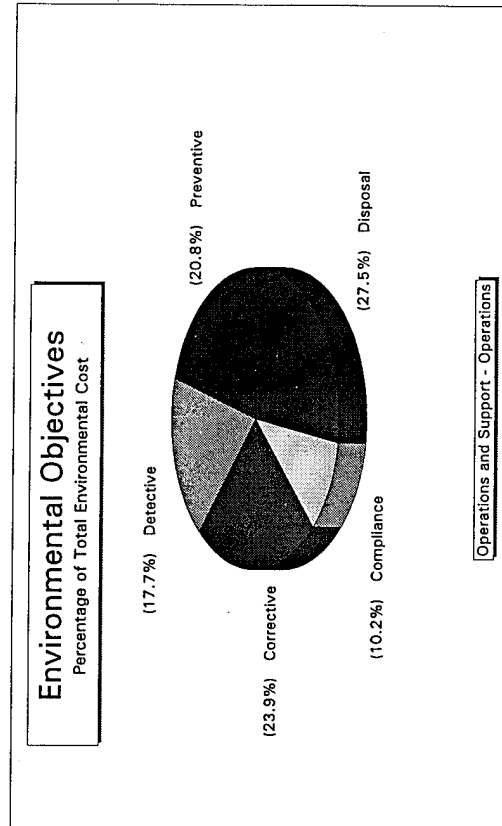
Environmental Life Cycle Cost Analysis Summary

Operations and Support

Operations and Support Function: Operations
Reference: 1.0

Activities			Environmental Objectives		
Activity	Activity Total Cost	Environmentally Driven % of Total	Environmental Cost	Type	Cost Impact %
1.1 Planning and Preparation	\$1,053	12.5%	\$132	Preventive	\$163 20.8%
1.2 Tactical Field Operations	\$922	22.5%	207	Detective	139 17.7%
1.3 Recovery from Field Operations	\$658	67.5%	444	Compliance	187 23.9%
				Disposal	80 10.2%
Total Activities	\$2,633	per round fired	\$783	Total Environmental	215 27.5%
				Total Operations	\$783 100.0%
				Total Environmental as a % of Total Operations	\$2,633

Note: 1. Cost elements based on battalion-level field operations and training for 155mm conventional munitions.



Operations and Support Function: Operations
Activity: Planning and Preparation

Reference: 1.11

Total Activity Cost : \$1,053
Environmentally Driven % of Total: 12.5%
Environmentally Driven Cost: \$132

Tasks: Service battery ammo pit operations, plan for misfiring, personnel planning, hazmat training, scheduling, inspect tracks, check vehicle maintenance, pre-combat inspections, fueling, inserting ammo loads, plan for human waste, reading ARTEP manual, paperwork for ammo issuance, pickup of ammo at ammo storage, plan for field level resupply

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	3.5%	\$37
Detective	3.0%	32
Corrective	4.0%	42
Compliance	2.0%	21
Disposal	0.0%	0
Total	12.5%	\$132 per round

Operations and Support Function: Operations
Activity: Tactical Field Operations

Reference: 1.21

Total Activity Cost : \$922
Environmentally Driven % of Total: 22.5%
Environmentally Driven Cost: \$207

Tasks: inspecting ammo loads, training, unpacking for field use, inspection of ammo, staff oversight, observe firing, safety checks, housekeeping, firing operations at firing point, occupy firing point, transfer of ammo from ammo handlers, feeding troops, personnel inspections, moving to firing points, NBC training, maintain field ammo storage, supply point distribution, react to ammo malfunctions, sorting ammo, troop leading activities, field resupply, plan and train for burning excess powder, powder change, inspect for equipment fluid leaks

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	6.5%	\$60
Detective	4.5%	41
Corrective	5.0%	46
Compliance	1.0%	9
Disposal	5.5%	51
Total	22.5%	\$207 per round

Operations and Support Function: **Operations**
 Activity: **Recovery from Field Operations**

Reference: 1.31

Total Activity Cost : \$658
 Environmentally Driven % of Total: 67.5%
 Environmentally Driven Cost: \$444

Tasks: deal with dunnage in field, perform ordnance checklists, turn-in of live ammo, wash vehicles, recover oil from washing, track maintenance, sort wastes for disposal, PMCS, dispose of powder cans, dispose of shipping plugs, account for sensitive weapons, wash rack, washing vehicles, cleanup of hydraulic fluid leaks, "mini" demil of returned materials, burn excess power in field, clean weapons, recover and store cleaning materials, recover and dispose of oily soil, account for residues, residue packaging, police firing points, residue yard operations, change oil and lube tracks, dispose of oil filters, break free, wash oily rags

Environmental Objectives:	% of Activity to Objectiv	Cost
Preventive	10.0%	\$66
Detective	10.0%	66
Corrective	15.0%	99
Compliance	7.5%	49
Disposal	25.0%	165

Total	67.5%	\$444 per round
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Environmental Life Cycle Cost Analysis Summary

Operations and Support

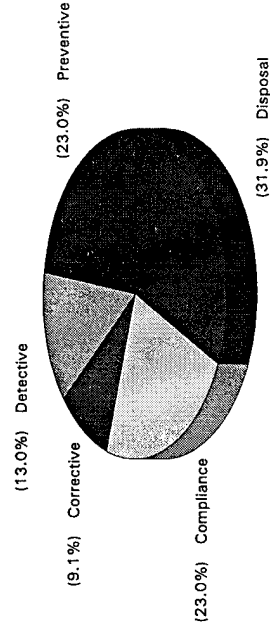
Operations and Support Function: Logistics
Reference: 2.0

Activities		Environmental Objectives		
Activity	Activity Total Cost	Environmentally Driven % of Total	Type	Cost Impact %
2.1 Planning and Preparation	\$41	20.0%	Preventive	\$7 23.0%
2.2 Tactical Field Operations	\$23	5.0%	Detective	4 13.0%
2.3 Recovery from Field Operations	\$27	75.0%	Compliance	3 9.1%
			Disposal	7 23.0%
Total Activities	\$91	per round fired		9 31.9%
		Total Environmental per round \$30 100.0%		
		Total Logistics per round \$91		
		Total Environmental as a % of Total Logistics 32.53% per round fired		

Note:

- Costs are for logistics operations in support of 155mm conventional artillery operations.

Environmental Objectives
Percentage of Total Environmental Cost



Operations and Support - Logistics

Operations and Support Function: **Logistics**
 Activity: **Planning and Preparation**

Reference: 2.11

Total Activity Cost : \$41 per round
 Environmentally Driven % of Total: 20.0%
 Environmentally Driven Cost: \$8 per round

Tasks: labeling, transportation of ammo, manifesting, rearranging warehouse, planning receipts of shipments, receive and unload ammo, throughput distribution, storage training, sorting ammo for use, personnel training, plan for misfiring, inspect tracks, check vehicle maintenance, pre-combat inspections, insert ammo loads, surveillance of ammo, documentation of warehouse training, storage of ammo at ammo handling area, coordinate issuance of ammo

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	10.0%	\$4
Detective	0.0%	0
Corrective	0.0%	0
Compliance	10.0%	4
Disposal	0.0%	0
Total	20.0%	\$8 per round
	=====	=====

Operations and Support Function: Logistics
 Activity: Tactical Field Operations

Reference: 2.21

Total Activity Cost : \$23 per round
 Environmentally Driven % of Total: 5.0%
 Environmentally Driven Cost: \$1 per round

Tasks: rewarehousing, inspecting ammo loads, training, staff oversight, safety checks,
 housekeeping, personnel inspections,

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	0.0%	\$0
Detective	5.0%	1
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	0.0%	0
<hr/>		
Total	5.0%	\$1 per round
=====		

Operations and Support Function: Logistics
 Activity: Recovery from Field Operations

Reference: 2.31

Total Activity Cost : \$27 per round
 Environmentally Driven % of Total: 75.0%
 Environmentally Driven Cost: \$20 per round

Tasks: ordnance checklists, turn-in of live ammo, power cans, shipping plugs, dunnage recovery, account for sensitive weapons, demil of returned materials, recover and store cleaning materials, vehicle cleaning, changing oil and lubing of vehicles, environmental cleanup, oil filter disposal, washing oily rags, sort wastes for disposal, track maintenance, PMCS, cleanup fluid leaks from vehicles, account for residuals, turn-in sensitive items

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	10.0%	\$3
Detective	10.0%	3
Corrective	10.0%	3
Compliance	10.0%	3
Disposal	35.0%	9

Total	75.0%	\$20 per round
=====		

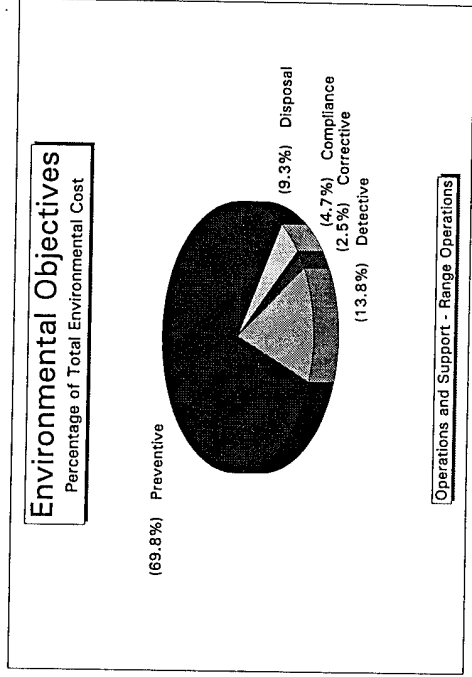
Environmental Life Cycle Cost Analysis Summary Operations and Support

Operations and Support Function: Range Operations
Reference: 3.0

Activities			Environmental Objectives		
Activity	Activity Total Cost	Environmentally Driven % of Total	Environmental Cost	Type	Cost Impact %
3.1 Radio and Inspector Operations	\$16	50.0%	\$8	Preventive	\$44 69.8%
3.2 Scheduling	\$5	20.0%	1	Detective	9 13.8%
3.3 Planning and Safety	\$5	25.0%	1	Corrective	2 2.5%
3.4 Target Operations	\$70	70.0%	49	Compliance	3 4.7%
3.5 Supply and Support	\$11	40.0%	4	Disposal	6 9.3%
Total Activities	\$107	per round	\$64	Total 155mm Environmental	\$64 100.0%
				Total 155mm Daily Costs	\$107
				Total Environmental as a % of Daily Total	59.49% per round fired

Note:

1. Costs are for range operations in support of 155mm conventional artillery training operations.
2. Assumption of 350 active training days per year.



Operations and Support Function: Range Operations
Activity: Radio and Inspector Operations

Reference: 3.11

Total Activity Cost : \$16
Environmentally Driven % of Total: 50.0%
Environmentally Driven Cost: \$8

Tasks: operations radio inspection, coordination of live fire ranges, tracer waiver paperwork, track number of rounds fired, cleaning process, site inspections, direct removal of contaminated soil, monitor sanctuary areas, coordination of radio room operations

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	0.0%	\$0
Detective	46.0%	7
Corrective	2.0%	0
Compliance	2.0%	0
Disposal	0.0%	0
Total	50.0%	\$8 per round

Operations and Support Function: Range Operations
 Activity: Scheduling

Reference: 3.21

Total Activity Cost : \$5
 Environmentally Driven % of Total: 20.0%
 Environmentally Driven Cost: \$1

Tasks: process training requests, scheduling paperwork, long range training calendar, communicate unit schedules, coordinate land management, maintain daily firing log, monitor 120 day schedule, schedule bird nesting restrictions, monitor environmental wildlife areas

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	17.0%	\$1
Detective	0.0%	0
Corrective	0.0%	0
Compliance	3.0%	0
Disposal	0.0%	0
Total	20.0%	\$1 per round
	=	=
	=	=
	=	=
	=	=
	=	=

Operations and Support Function: Range Operations
 Activity: Planning and Safety

Reference: 3.31

Total Activity Cost : \$5
 Environmentally Driven % of Total: 25.0%
 Environmentally Driven Cost: \$1

Tasks: control damage area for overhead firing, crater analysis, marking target areas, destroying duds in buffer area,
 monitoring out-of-area firing, surface sweeping in permanently duded area, direct firing in duded area,
 control white phosphorous firings, placing targets in impact areas, monitoring target placement

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	20.0%	\$1
Detective	0.0%	0
Corrective	0.0%	0
Compliance	0.0%	0
Disposal	5.0%	0
Total	25.0%	\$1 per round
	=====	=====

Operations and Support Function: Range Operations
Activity: Target Operations

Reference: 3.41

Total Activity Cost : \$70
Environmentally Driven % of Total: 70.0%
Environmentally Driven Cost: \$49

Tasks: Target servicing, range vehicle maintenance, operate and maintain target ranges, operate and maintain targets, construct and paint targets, accompanying/guiding fire fighters, conduct environmental briefings

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	60.0%	\$42
Detective	2.0%	1
Corrective	1.0%	1
Compliance	2.0%	1
Disposal	5.0%	4
Total	70.0%	\$49 per round
	=====	=====

Operations and Support Function: Range Operations
Activity: Supply and Support

Reference: 3.51

Total Activity Cost : \$11
Environmentally Driven % of Total: 40.0%
Environmentally Driven Cost: \$4

Tasks: Build targets, paint targets, paperwork, maintain supplies

Environmental Objectives:	% of Activity to Objective	Cost
Preventive	5.0%	\$1
Detective	0.0%	0
Corrective	5.0%	1
Compliance	10.0%	1
Disposal	20.0%	2
Total	40.0%	\$4 per round

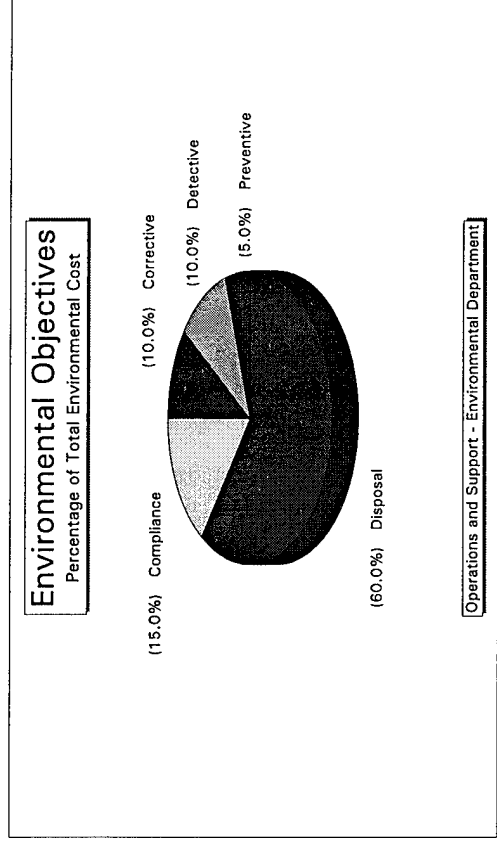
Environmental Life Cycle Cost Analysis Summary Operations and Support

Operations and Support Function: Environmental Division
Reference: 4.0

Activities		Environmental Objectives		
Activity	Activity Total Cost	Environmentally Driven % of Total	Environmental Cost	Type
Permitting, inspections, conduct training, emergency response remediation, interface with regulatory agencies, paperwork, reporting	\$37	100.0%	\$37	Preventive
				Detective
				Compliance
				Disposal
Total Activities	\$37	per round	\$37	
				Total 155mm Environmental
				Division cost per round fired
				\$37 100.0%

Note:

- Costs are for support of tactical operations only and relate specifically to 155mm conventional artillery operations.



Appendix D

Demilitarization

Primary Location: n/a

Assumptions:

1. The Demilitarization phase is not addressed at this stage of the environmental life cycle costing project due to the fact that demilitarization requires a specific plan of activities and tasks to be carried out. At the present time, this demilitarization plan is under development. No assessment of future environmental costs associated with demilitarization is possible until the specific elements of this plan are known.